"Development of a Minimum Performance Standard for Handheld Fire Extinguishers as a Replacement for Halon 1211 on Civilian Transport Category Aircraft"

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ABSTRACT

One or more Halon 1211 extinguishers are specified in FAR part 25.851 as a requirement on transport category aircraft with 31 or more seats. Halon 1211 has been linked to the destruction of the ozone layer and production of new Halon 1211 has been halted per the Montreal Protocol in 1993. The phase out of Halon 1211 as the hand held fire-fighting agent of choice for civilian transport category aircraft has necessitated the development of a Minimum Performance Standard to evaluate replacement agents. The purpose of the MPS is to insure that there is no reduction in safety, both in terms of effectiveness in fighting onboard fires and toxicity to the passengers and crew.

The MPS specifies two new tests that replacement agents must pass in addition to national certifications such as Underwriters Laboratories. The first test evaluates the "flooding" characteristics of the agent. This test determines the ability of a streaming agent to function as a flooding agent. The second test evaluates the performance of the agent in fighting a terrorist scenario fire and the associated toxicity hazard. This test measures the agent's ability to extinguish a triple seat fire in an aircraft cabin under in-flight conditions, and the toxicity characteristics of both the neat agent and the products of decomposition.

This Minimum Performance Standard will insure that the replacement agents will meet or exceed the performance of Halon 1211 both in fighting fires and maintaining a safe breathing environment in aircraft cabins.

INTRODUCTION

The purpose of this standard is to provide a method to evaluate the performance of hand held fire extinguishers required on transport category aircraft. Currently, regulations require that Halon 1211, or equivalent, hand held fire extinguishers be carried in the passenger cabin of transport aircraft. The regulation states that the type and quantity of agent, if other than Halon 1211, must be appropriate for the kind of fires likely to occur where used.

The requirement for Halon 1211 had its origins with enhancing in-flight fire fighting capability, including the need to deal with the arsonist/hijacking threat which was prevalent in the 1970's. Testing performed at the FAA Technical Center identified Halon 1211 as a superior extinguishing agent for the hijacking/arsonist scenario when compared to the CO2 and dry chemical extinguishers then commonly in use. [1] Later, it was determined that Halon 1211 in hand held extinguishers, while primarily a streaming agent, provided the capacity to act as a flooding agent. This was demonstrated on an in flight cheek area fire in a large transport aircraft, possibly preventing the loss of the aircraft.

The 1987 Montreal Protocol, an international treaty, was established to control the release of substances that damage the stratospheric ozone layer. As a result, the production of Halon 1211,1301 and 2402 fire fighting agents was phased out in all industrialized countries in 1993. Halon 1211 is still available from stock piled and recycled sources but will be phased out as a suitable replacement is developed. This standard describes the tests required to show that the performance of the replacement agents equals or exceeds the performance of the current Halon 1211 fire extinguishers.

The tests described in this standard are one part of the total FAA/JAA certification process. Compliance with other applicable regulations, some of which are listed below, is also required. Applicants attempting to certify replacement fire extinguishers are encouraged to discuss the required process with regulatory agencies prior to conducting testing.

Minimum Performance Standard for Handheld Fire Extinguishers

SCOPE

The MPS seeks to insure that there is no loss of safety to the flying public by the removal of Halon 1211. All replacement extinguishers must meet the certification requirements of a national listing organization, such as Underwriter's Laboratory standard UL 711 or the British standard BS 3A:34B. This insures a fire fighting capability equal to a UL 5-B:C rated 2.5 lb. Halon 1211 fire extinguisher. In addition, the agent must demonstrate that it is acceptable in two additional tests that are specific to aircraft use described in this MPS.

(1) Hidden Fire Test. The extinguisher must be able to extinguish fires in indirectly accessible spaces ("hidden" fires) as effectively as the currently required Halon 1211 2.5 lb. 5 BC rated extinguisher. Handheld extinguishers are by nature streaming agents. Halon 1211 has the ability to also function as flooding agent. To insure no loss of safety, replacement agents must maintain this ability. A hidden fire test has been developed to assess the fire fighting performance of the handheld extinguisher / agent combination in a flooding scenario.

(2) Seat Fire / Toxicity Test. The extinguisher must have an acceptable toxicity for use where people are present. In particular, the combined toxicity of the agent and fire products must not be unacceptable for use in an aircraft cabin under in-flight conditions. A test has been developed to measure the toxicity of the agent and it products of decomposition when extinguishing a seat fire in an aircraft cabin.

APPLICABLE REGULATIONS.

The following existing FAR's/JAR's pertain to hand held portable extinguishers as required for transport aircraft:

Airworthiness Standards:
- Transport Category Airplanes, Part 25.851
- Normal, Utility, Acrobatic and Commuter Airplanes, Part 23.851
- Transport Category Rotorcraft, Part 29.851

Operating Requirements:
- Domestic, Flag, and Supplemental Operations, Part 121.155
- Commuter and On-Demand Operations, Part 135.155

Part 25.851 specifically requires that on or more Halon 1211 fire extinguishers be carried on air transport category aircraft with more than 31 passenger seats.

AGENT SELECTION GUIDELINES

(1) Fire Type. The agent must be suitable for fighting materials fires typical of those encountered on commuter and transport aircraft cabins, lavatories, accessible baggage compartments and flight decks. In hand held configuration, the agent must exhibit streaming as well as some flooding characteristics.

(2) Environmental Concerns. Airworthiness Requirements specifically call for Halon 1211 or equivalent portable fire extinguishers for in flight fire fighting. Halon 1211 has been identified as one of a number of chemicals responsible for depletion of the ozone layer. Under the provisions of the Montreal Protocol, production of Halon 1211 has effectively been halted. Any new agents considered as a replacement for Halon 1211 must be environmentally friendly. The environmental characteristics of a replacement agent that need to be addressed are: Ozone Depletion Potential (ODP), Global Warming Potential (GWP), and Atmospheric Lifetime. This performance standard addresses only the fire fighting effectiveness of the agent.

(3) Toxicology. The replacement agent must be designed to minimize the hazard of toxic gas concentration when discharged in an aircraft cabin.

(4) Extinguisher Rating. The candidate extinguisher must be approved by a recognized fire testing laboratory and have a minimum rating of UL 5BC, or an equivalent rating to 2.5 pounds of Halon 1211.

PERFORMANCE TESTS

(1) Hidden fire Test. (appendix 1)

The Hand held Hidden Fire Test is designed to determine the performance of the agent / extinguisher in a flooding scenario. The test is comprised of 20 nheptane cup fires in a three dimensional array separated by perforated baffles. The cup fires are allowed to burn for 30 seconds before the extinguisher is discharged from a fixed location on the left side of the apparatus. The number of fires extinguished is tallied. Baseline testing with Halon 1211 resulted in 9 fires extinguished.

(2) Seat Fire / Toxicology Test. (appendix2)

The Seat Fire / Toxicology test is designed to evaluate the type and concentrations of toxic gases formed when the agent is used to extinguish a typical seat fire under airflow conditions normally found in an aircraft cabin. The test will be performed in the TC-10 test article at the FAA Technical Center. The test conditions include a triple aircraft seat that has been fire blocked. The seat is primed with one quart of gasoline and ignited. The fire is allowed to burn for thirty seconds before being extinguished. Instrumentation is provided to measure the products of decomposition, CO, CO_2, O_2 and the concentration of the neat agent in the cabin. Baseline testing will be performed with Halon 1211 to determine acceptable levels of exposure.

TEST DEVELOPMENT STATUS

(1) Hidden Fire Test.

Extensive testing was performed in the hidden fire test article to determine the operating parameters and develop a baseline using Halon 1211. A standard operating test procedure was developed, as well as pass /fail criteria (appendix 1).

a. Effect of nozzle orientation: Varying the extinguisher nozzle by more than 5 degrees in either the vertical or horizontal plane results in a decrease in the number of cups extinguished. Care must be taken to insure that the nozzle is oriented normal to the face of the test article.

b. Fixture temperature: Temperatures greater than 90 degrees F in the test fixture result in increased extinguisher performance. Temperatures as high as 150 degrees resulted in nearly twice as many cups extinguished as at 75 degrees. The test fixture must be allowed to return to a temperature of 70-90 degrees between tests.
c. Effect of pre-burn. Preburn is defined as the elapsed time from when the cups are ignited and the doors closed to when the extinguisher is discharged. The test is sensitive to preburn times longer than 50 seconds (Figure 1). Beyond 50 seconds, the performance of the extinguisher increases quickly. Care must be taken to adhere to the 30 second preburn specified in the procedure.
d. Preliminary testing with alternate agents has demonstrated the ability of the test to differentiate performance.

<u>Status</u>

The draft test method is described in appendix 2.

(2) <u>Seat Fire / Toxicology Test</u>

The basic parameters for this test were developed at the FAA Technical Center as described in the 1982 report authored by Richard G. Hill and Louise C. Speitel, "In-Flight Aircraft Seat Fire Extinguishing Tests (Cabin Hazard Measurements)." The test has been modified somewhat to comply with current regulations. The most notable changes are the use of fire blocked seats, extending the preburn to thirty seconds and using a live fire fighter to apply the agent (appendix 2).

<u>Status</u>

a. The draft test procedure has been developed and is described in appendix 2.
b. The instrumentation is complete and operational.
c. Preliminary baseline testing with uncontrolled fires is underway.
d. Preliminary baseline testing with Halon 1211 is underway.
e. Development of toxicology pass/fail criteria is in progress.

<u>Test Results</u>

a. Uncontrolled Fire

Initial uncontrolled baseline testing revealed some unacceptable scatter in the toxic gas data. It is expected that increased control over the application of the gasoline to the seat bottom will reduce the deviation. The data being presented here should be considered preliminary until a repeatable standard fire is established. Figures 2,3 and 4 illustrate the levels of toxic gas concentrations that are given off by the fire blocked seat and one quart of gasoline when the fire is allowed to burn for five minutes.

Gas Data Peak Values:

Oxygen Depletion: None
Carbon Dioxide: 0.3%
Carbon monoxide: 0.16%

Cabin Temperature Peak Value (ceiling):

b. Controlled Fire

Initial Halon 1211 tests were run to proof the test procedure and verify the data collection methods. Additional tests will be run once the fire has been standardized to develop a baseline. Figures 5, 6 and 7 are the levels of toxic gases recorded when the fire was extinguished after 30 seconds.

Gas Data Peak Values:

Oxygen Depletion: None
Carbon Dioxide: 0.4%
Carbon Monoxide: 0.04%
Halon 1211: 0.12%

Cabin Temperature Peak Value: 98 Degrees Fahrenheit

Schedule

a. Development of standard fire: November, 1998
b. Establishment of Halon 1211 baseline: December 1998 /January 1999.
c. Testing of alternate agents: February/March 1999.

Figure 1

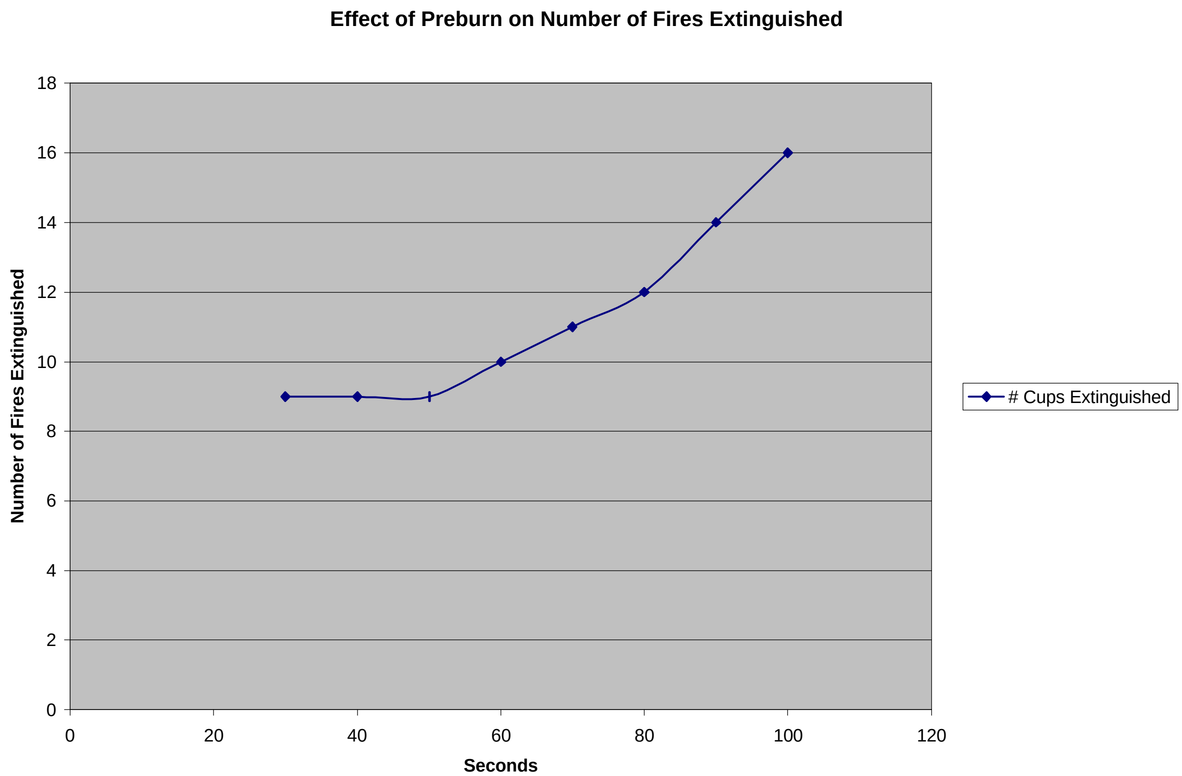


Figure 2.

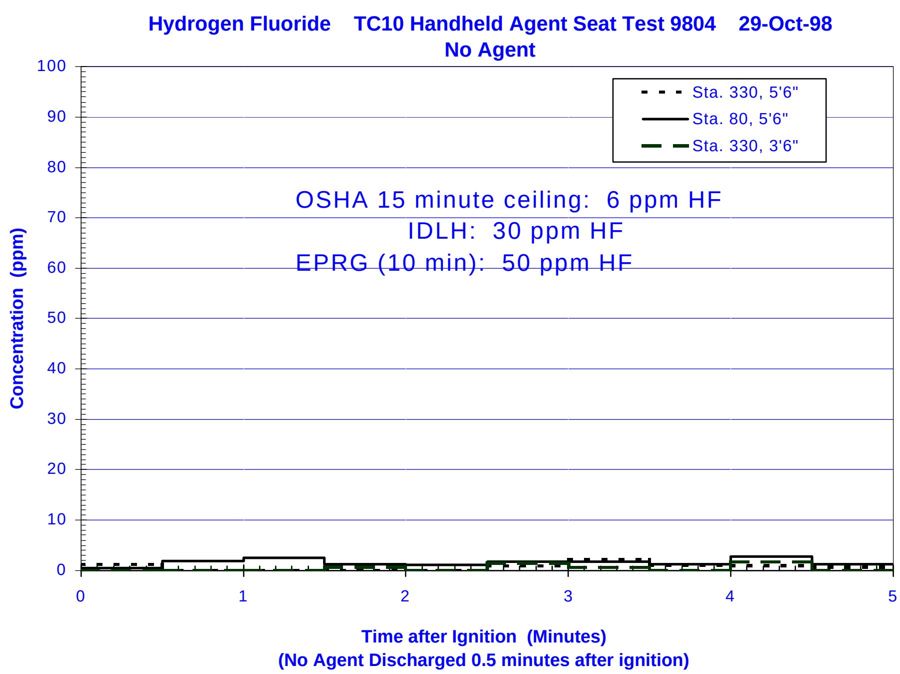


Figure 3.

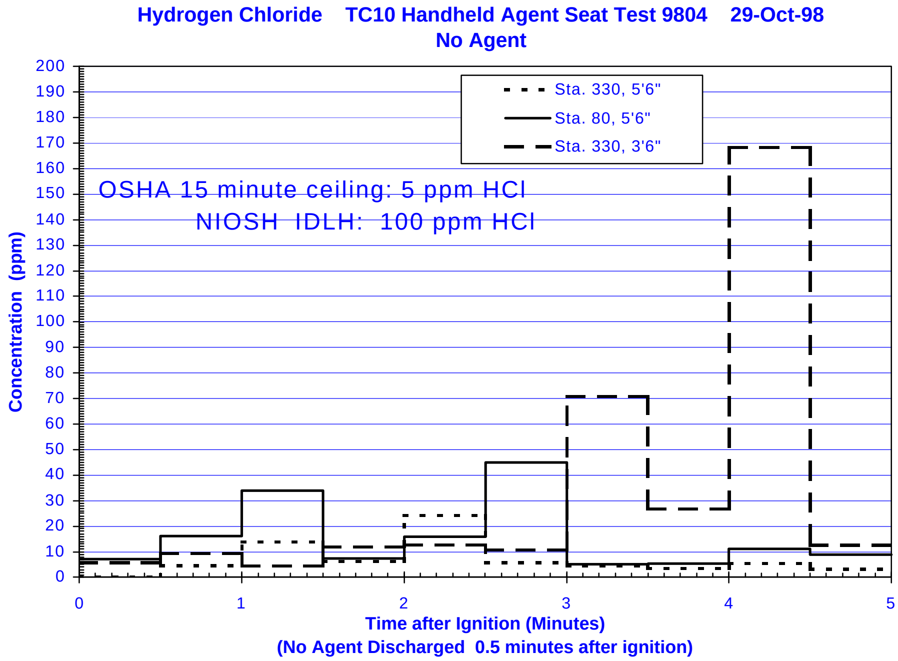


Figure 4.

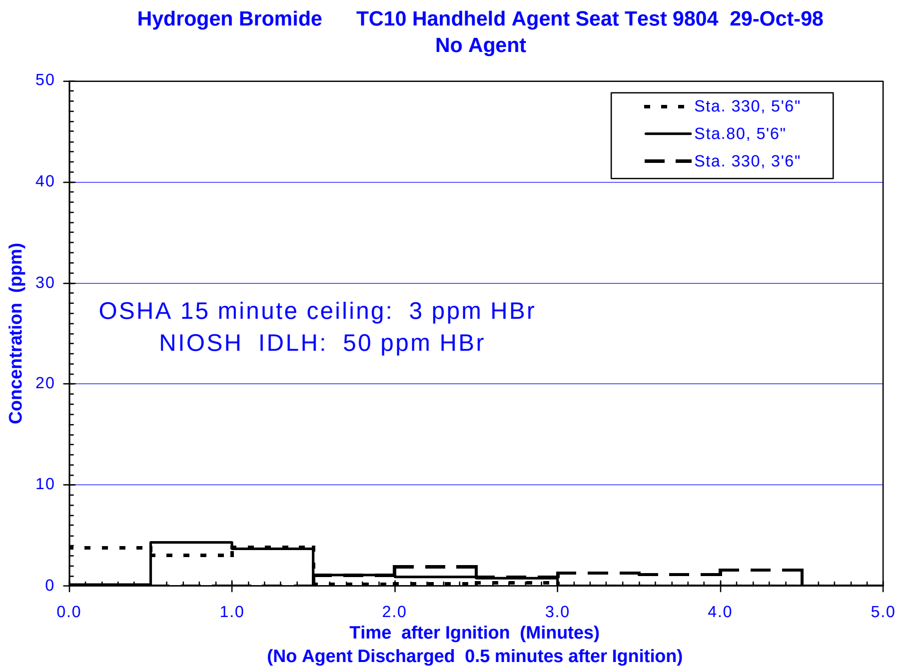


Figure 5.

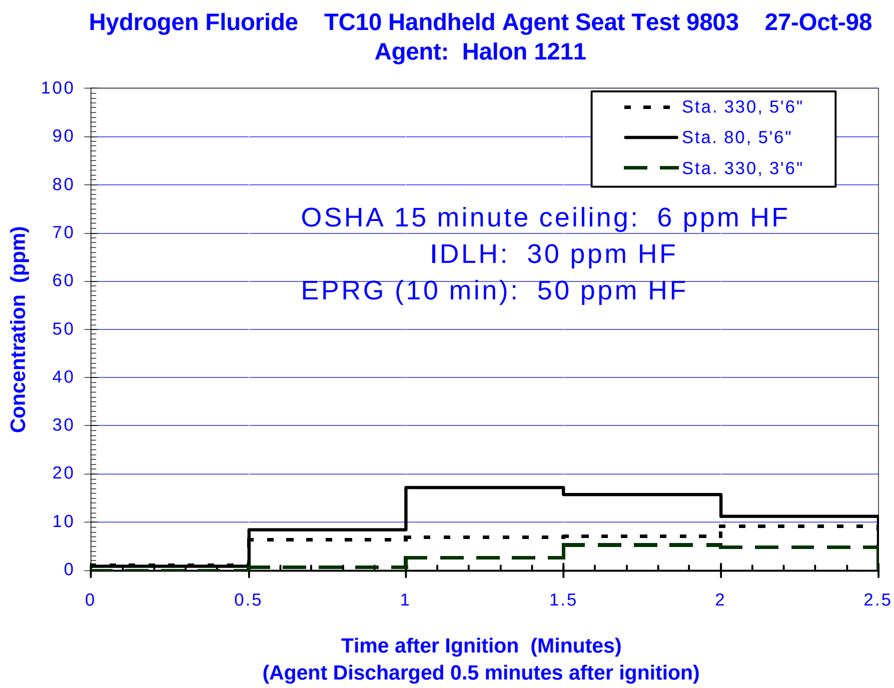


Figure 6.

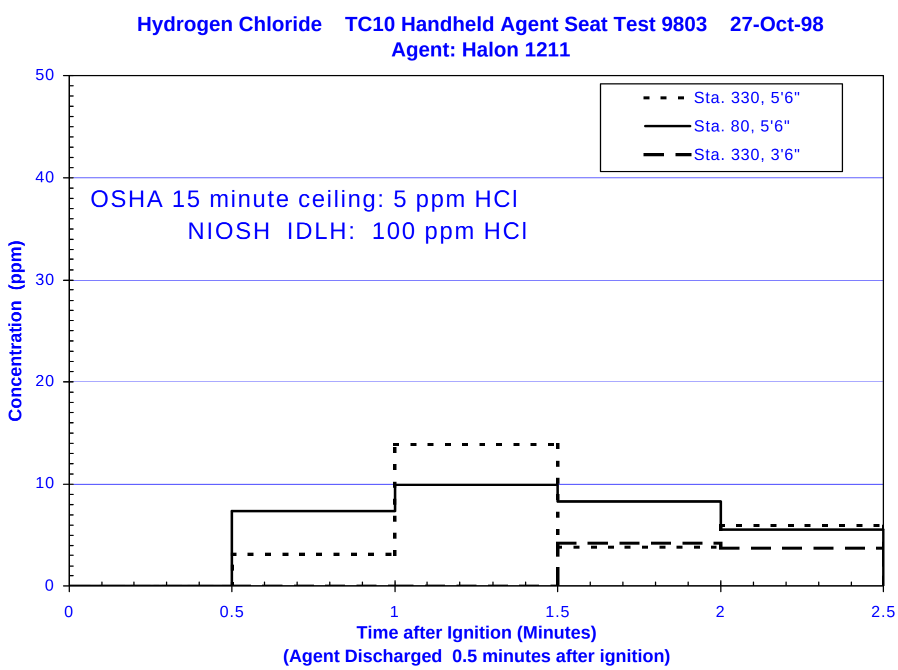
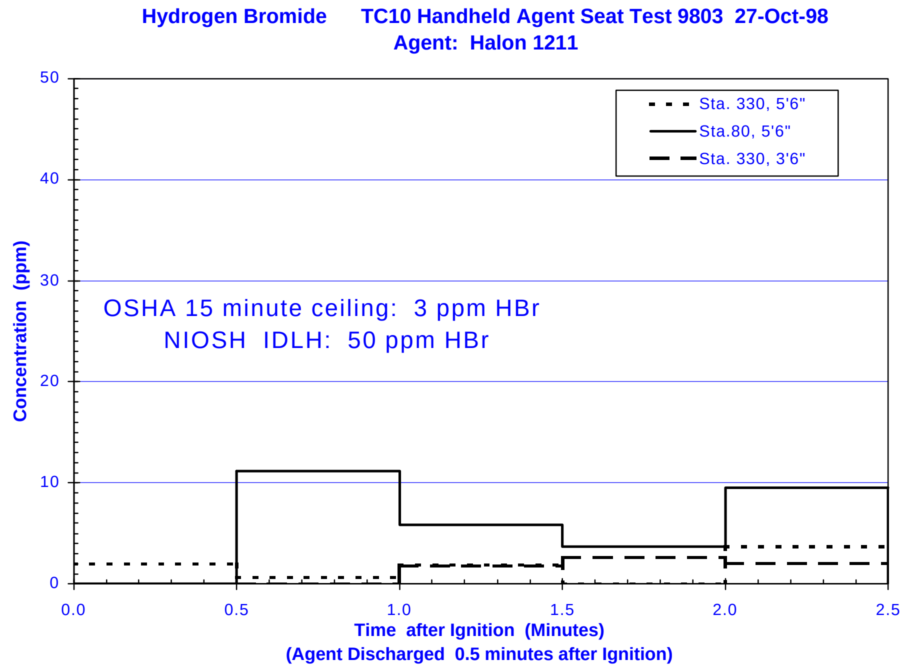


Figure 7.



Development of a Pass / Fail Criteria for the Seat / Toxicology Test

A maximum limit must be established for exposure of the passengers and crew to toxic gas fumes.

The selection of Exposure Limit criteria is open to some debate. There are two exposure limit systems that seem relevant to the discharge of a fire extinguisher in an aircraft cabin while fighting a fire. They are the IDLH and the ERPG, defined as follows:

IDLH: This limit is published by The National Institute for Occupational Safety and Health (NIOSH): Immediately Dangerous to Life and Health (IDLH). The definition is as follows: “a condition that poses a threat of exposure to airborne contaminants when that exposure is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such an environment.’ The referenced exposure time is thirty minutes, although exposure at the published IDLH levels is not recommended for that amount of time. (ref 3)

ERPG: This limit is designed for use to evaluate the potential health significance of accidental releases, which may impact the general population. ERPG stands for Emergency Response Planning Guidelines, developed by the American

Industrial Hygiene Association.   EPRG is a three level system defined by the effects of the exposure. (ref 4)

ERPG - 1 : the maximum airborne concentration below which nearly all individuals could be exposed for up to 1 hour without experiencing more than mild, transient adverse health effects or without perceiving a clearly defined objectionable odor.

ERPG - 2 : the maximum airborne concentration below which nearly all individuals could be exposed to for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action.

ERPG - 3 : the maximum concentration below which nearly all individuals could be exposed for up to one hour without experiencing or developing life threatening health effects.

ERPG –2 seems to be reasonable in the context of this standard. It should be noted that the ERPG limits do not contain the safety factors usually built into recommended exposure levels.

Comparison of IDLH and ERPG exposure levels: (ppm)

	IDLH	ERPG-1	ERPG-2	ERPG-3	Halon 1211
HBr	30	(none)	(none)	(none)	11
HCl	50	3	20	150	14
HF	30	2	20	50	17

The exposure time in an aircraft cabin with operating ventilation system is likely to be under fifteen minutes, with the peak concentration exposure considerably less.

The selection of an exposure limit criteria is under development and has not been finalized at this time.

REFERENCES

1. Hill, Richard G., Speitel, Louise C., In-Flight Aircraft Seat Fire Extinguishing Tests (Cabin Hazard Measurements), FAA Report No. DOT/FAA/CT-82/111, December 1982.

2. Chattaway, A., The Development Of A Hidden Fire Test For Aircraft Hand Extinguisher Applications, Research Report No. R95/11, November 1995.

3. NIOSH Pocket Guide to Chemical Hazards, NIOSH/CDC, 1997.

4. DiNardi, S., The Occupational Environment- Its Evaluation and Control, AIHA, 1997.